

## ENVIRONMENTAL CONTAMINATION OF HEAVY METALS IN SOME DRIED FISH OF COASTAL REGIONS OF BANGLADESH

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**Abstract:** Heavy metals are non-biodegradable substances which cause serious carcinogenic effects on animals and humans. As fish occupy top position of aquatic food chain, it is a major source of heavy metal contamination. The concentration of Cd, Cr, Pb, Mn, Fe, Cu, and Zn were 0.0156 - 0.1428, 0.163 - 8.53, 0.0924 - 0.4026, 9.38 - 65.9382, 0.0473 - 0.1981 and 0.1473 - 1.8148 ppm respectively for the fish samples of Cox's Bazar region while 0.0191 - 0.1386, 0.8445 - 0.1743, 0.102 - 0.4625, 0.102 - 0.4675, 9.7269 - 60.5267, 0.3108 - 0.046 ppm for the fish samples of Saint Martin's region. Comparatively high concentrations of heavy metals were found to be accumulated in Mola (*Amblypharyngodon mola*), Rupchanda (*Stromateus chinensis*) and Chhuri (*Trichiurus lepturus*). The order of heavy metal concentrations were Fe > Zn > Cr > Cu > Mn > Cd. The concentration of heavy metals varied from species to species and most of the metals were not significantly correlated, even some metals showed negative correlation among them. Concentration of Fe in some fishes (Mola, Rupchanda and Chhuri) was found higher than WHO guideline values, while other metals exhibited the value below the WHO standard. The results of this study will assist in acquiring information about the level of toxic metals in these regions and to improve the coastal management in these areas in future.

**Key words:** Pollution, heavy metals, dried fish, coastal regions

### INTRODUCTION

Fish is a valuable and cheap source of protein to man and dried marine fish has been a favored delicacy option especially in Bangladesh. Bangladesh is a tide delta with a 710 km coast along the Bay of Bengal with one of the richest continental shelf zones of the world. The marine environment of Bangladesh is an important issue in the context of ecological disturbances and climate change.

The Bay of Bengal has the potential for its vast coastal communities and diversity is now subjected to different anthropogenic pollutants (Hossain *et al.* 2018). The rapid development of industrialization has resulted in heavy metal pollution in our coastal water bodies, which is a significant environmental hazard for invertebrates, fish and humans (Uluturhan and Kucuksezgin 2007). Coastal areas are the most pollution prone zones around the world. The coast of

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Bangladesh is known as a zone of multiple vulnerabilities due to various forms of pollution which made the whole coastal and marine environment vulnerable (Islam *et al.* 2015). The marine and coastal pollution emerges mainly from the ships, industrial effluents, sewerage discharge, untreated effluents, e-waste and open dumping. The precipitation funnels the pollutants into the open sea and finally deposit into sediment. During flood events or current, the sediments release pollutants into water column and finally affect the health of the ocean.

In a food chain fish are important component to transfer heavy metals from one trophic level to another. The heavy metals from the marine environment bio-accumulate in fish and finally get a way to human body causing serious health hazards.

Numerous studies have been carried out on metal pollution in different species of edible fish (Rahman *et al.* 2012, Amundsen 1997). Heavy metals like Pb and Cd, are non-essential metals, may exhibit extreme toxicity, even in trace concentrations under certain conditions, require regular monitoring of sensitive aquatic environments (Cid *et al.* 2001). Thus, only three metals, Pb, Cd and Hg, have been included in the regulations of the European Union for hazardous metals (EU 2008). Metals such as Cu and Zn are essential metals, since they play an important role in biological systems. The heavy metals with known deleterious effects should fully exclude from the food for human consumption. In this present study, authors investigated the concentrations of Pb, Cd, Cr, Mn, Fe, Cu and Zn in different species of dried fish such as Chhuri (*Trichiurus lepturus*), Lauita (*Harpodon nehereus*), Mola (*Amblypharyngodon mola*), Gonia (*Chandramara chandramara*), Sundori (*Nemipterus vigatus*), Bashpati (*Devario devario*) and Rupchanda (*Stromateus chinensis*) collected from different fish markets of Cox's Bazar and Saint Martin's regions.

As dried fish occupy a distinct place as a delicacy in Bangladesh dishes and technologies in harvesting, and processing remains crude, there is need to assess their probable contamination with heavy metals as well as the risk associated with their consumption. Several works on heavy metal contamination have been carried out (Ali *et al.* 2016, Ahmad *et al.* 2010, Rahman *et al.* 2012, Begum *et al.* 2013). But limited information is available on heavy metal contamination in coastal dried fish species. The present study investigates the state of heavy metal pollution in dried fish species in coastal regions and provides necessary information regarding the safety of dried fish to achieve food security.

### MATERIAL AND METHODS

Dried fish samples were collected from the local fish markets of Cox's Bazar and St. Martin's Regions. It is located 150 km south of the industrial port Chittagong. St. Martin's regions are a small region in the north eastern part of the Bay of Bengal, about 9 km south of the tip of the Cox's Bazar-Teknaf peninsula, and forming the southern-most part of Bangladesh.

Traditionally dried marine fishes such as Chhuri (*Trichiurus lepturus*), Lauita (*Harpodon nehereus*) and Mola (*Amblypharyngodon mola*), Gonia (*Chandramara chandramara*), Sundori (*Nemipterus vigatus*), Bashpati (*Devario devario*), Rupchanda (*Stromateus chinensis*) were collected from the local markets of Cox's Bazar and Saint Martin's Regions (Fig. 1). Prior to sampling the polyethylene bags were washed with 1M HNO<sub>3</sub> solution and rinsed thoroughly with distilled water. The samples were properly labelled and preserved at -20°C to avoid the risk of hydrolysis and oxidation.



Fig. 1. Dried fish samples collected from different markets of Cox's Bazar and Saint Martin's regions.

The preserved dried fish samples were further dried under the sun for 2 - 4 days to remove water and then cut into small pieces followed by grinding. Dried fish samples were digested with concentrated HNO<sub>3</sub> and concentrated HClO<sub>4</sub> for heavy metal determination. Briefly, about 0.5 g of each homogenized fish

samples were measured into separate beaker. Then 8 ml of concentrated HNO<sub>3</sub> (65%) and 4 ml of HClO<sub>4</sub> (70%) was added into the beaker. The mixture was mixed gently and allowed to digest on a hot plate in a fume chamber for 2 hrs at 70°C until the brown fumes disappeared. The digested samples were filtered through the Whatman filter paper and each solution made up to 50 ml with deionized water and kept ready for Atomic Absorption Spectrophotometer (AAS) (AA-6300, Shimadzu, Japan) analysis.

Spearman's rank correlation matrix was used to calculate the correlation among the heavy metals in fish samples and the differences among the means of concentrations in fishes were analysed by one-way ANOVA, followed by post-hoc test by Dunnett's test.

## RESULTS AND DISCUSSION

Ten species of dried fish collected from Cox's Bazar and Saint Martin's regions were analysed for heavy metals to characterise and evaluate the state of heavy metal contamination. Table 1 showed the concentration of heavy metals (Cd, Cr, Pb, Cu, Mn, Fe, Zn) in the fish samples from Cox's Bazar.

**Table 1. Concentration of heavy metals in fish samples collected from different fish markets of Cox's Bazar**

Fish samples/heavy metals	Concentration (ppm)						
	Cd	Cr	Pb	Mn	Fe	Cu	Zn
Loittyta	0.029 ± 0.003	0.323 ± 0.09	BDL	0.0924 ± 0.01	9.3841 ± 1.41	0.1031 ± 0.05	0.3084 ± 0.13
Mola	0.0179 ± 0.007	0.3072 ± 0.05	BDL	0.1105 ± 0.07	52.773 ± 823	0.0473 ± 0.01	0.1473 ± 0.04
Bashpati	0.0456 ± 0.01	0.7415 ± 0.01	BDL	0.3196 ± 0.12	20.2737 ± 3.86	0.2167 ± 0.110	1.3373 ± 0.09
Gonia	0.0545 ± 0.02	0.3657 ± 0.06	BDL	0.2259 ± 0.17	10.004 ± 4.95	0.2632 ± 0.05	1.8146 ± 0.08
Sundori	0.0209 ± 0.001	0.3702 ± 0.01	0.2571 ± 0.001	0.3905 ± 0.16	18.9268 ± 2.57	0.185 ± 0.02	1.5708 ± 0.61
Churi	0.0156 ± 0.006	0.5502 ± 0.13	BDL	0.4026 ± 0.153	65.9382 ± 9.35	0.1925 ± 0.06	0.1535 ± 0.05
Chepa	0.0309 ± 0.001	0.5255 ± 0.23	0.1605 ± 0.007	0.2884 ± 0.09	29.8327 ± 5.12	0.1608 ± 0.08	0.5774 ± 0.162
Rupchanda	0.0191 ± 0.008	8.5352 ± 2.75	0.0277 ± 0.003	0.3088 ± 0.162	19.6859 ± 6.62	0.1571 ± 0.04	0.615 ± 0.164
Fatra	0.1428 ± 0.07	0.163 ± 0.08	0.0277 ± 0.003	0.2235 ± 0.05	15.5554 ± 6.43	0.1664 ± 0.08	0.9106 ± 0.231
Phasa	0.0633 ± 0.011	0.1788 ± 0.04	0.0277 ± 0.009	0.2042 ± 0.031	13.056 ± 2.72	0.1981 ± 0.02	1.7525 ± 0.94
Standard	0.1 µf/g		0.30 mg/kg	15 µg/g			
References	EU 2008		Eu 2008	Tuzen and Sylak 2007			

Among the fish species high amount of heavy metals were accumulated in Mola (*Amblypharyngodon mola*), Rupchanda (*Stromateus chinensis*) and Chhuri (*Trichiurus lepturus*). Fe was found in greater concentration than that of other heavy metals.

Among the 7 heavy metals in dried fishes from Cox's Bazar and Saint Martin's regions, Fe was the highest and Cd was the lowest, while Zn, Cr, Cu and Mn were moderate in concentration and Pb was found lower the detection limit (LOD).

*Loitty fish*: For Cox's Bazar samples, Fe and Cd concentration were 9.384 and 0.0291ppm while for the samples from Saint Martin's regions, Fe and Cd concentration were 12.9677 and 0.026 ppm, respectively (Tables 1 and 2). In fish from both regions, the concentration hierarchy of the heavy metals were Fe > Zn > Cr > Cu > Mn > Cd > Pb (Tables 1 and 2).

**Table 2. Concentration of heavy metals (Mean  $\pm$  Sd) in fish samples collected from different fish markets of Saint Martin's regions**

Fish samples/ Heavy metals	Concentrations (ppm)						
	Cd	Cr	Pb	Mn	Fe	Cu	Zn
Loitty	0.0226 $\pm 0.03$	0.3117 $\pm 0.09$	BDL	0.102 $\pm 0.03$	12.9677 $\pm 0.02$	0.0566 $\pm 0.02$	0.194 $\pm 0.01$
Mola	0.0232 $\pm 0.06$	0.314 $\pm 0.01$	BDL	0.4675 $\pm 0.02$	9.7269 $\pm 0.01$	0.0454 $\pm 0.01$	0.311 $\pm 0.04$
Bashpati	0.0597 $\pm 0.005$	0.7505 $\pm 0.02$	BDL	0.3316 $\pm 0.033$	21.0573 $\pm 0.014$	0.2167 $\pm 0.45$	1.424 $\pm 0.05$
Gonia	0.0256 $\pm 0.01$	0.746 $\pm 0.02$	BDL	0.3268 $\pm 0.022$	21.0084 $\pm 0.01$	0.2092 $\pm 0.32$	1.394 $\pm 0.3$
Sundori	0.0592 $\pm 0.06$	0.4872 $\pm 0.03$	0.2692 $\pm 0.02$	0.3833 $\pm 0.014$	19.1961 $\pm 0.013$	0.2297 $\pm 0.52$	1.791 $\pm 0.04$
Churi	0.0191 0.03	0.539 $\pm 0.012$	0.1243 $\pm 0.03$	0.3917 $\pm 0.02$	20.5267 $\pm 0.014$	0.3172 $\pm 0.04$	1.56 $\pm 0.006$
Chepa	0.0226 $\pm 0.06$	0.196554 $\pm 0.3$	0.2088 $\pm 0.013$	0.2944 $\pm 0.05$	301103 $\pm 0.01$	0.1013 $\pm 0.01$	0.605 $\pm 0.14$
Rupchanda	0.0221 $\pm 0.022$	0.1743 $\pm 0.015$	0.4625 $\pm 0.03$	0.2968 $\pm 0.01$	30.3143 $\pm 0.04$	0.2278 $\pm 0.05$	0.599 $\pm 0.05$
Fatra	0.1339 $\pm 0.011$	0.1968 $\pm 0.023$	0.397 $\pm 0.011$	0.2078 $\pm 0.012$	16.4778 $\pm 0.03$	0.5108 $\pm 0.11$	0.928 $\pm 0.35$
Phasa	0.1386 $\pm 0.07$	0.84452 $\pm 0.05$	0.4021 $\pm 0.034$	0.2114 $\pm 0.02$	16.0778 $\pm 0.055$	0.1161 $\pm 0.54$	0.496 $\pm 0.44$
Standard	0.1 $\mu\text{g/g}$		0.30 mg/kg	15 $\mu\text{g/g}$			
References	EU 2008		EU 2008		Tuzen and Sylak 2007		

*Mola fish*: In Cox's Bazar samples, the highest amount of Fe (52.773 ppm) and the lowest Cd (0.0179 ppm) was found. The concentration of Pb was below the detection level. The concentration hierarchy of the heavy metals were Fe > Cr

> Zn > Mn > Cu > Cd > Pb, respectively. Similarly, samples from Saint Martin's regions exhibited the highest amount of Fe (9.7269 ppm) and the lowest Cd (0.0232 ppm) (Tables 1 and 2).

*Bashpati fish:* Bashpati accumulated the highest amount of Fe (20.2737 ppm) and the lowest Cd (0.0456 ppm) in samples from Cox's Bazar while in samples from Saint Martin's regions Fe was dominant in concentration (21.0573 ppm). In both samples, the concentration hierarchy of heavy metals were Fe > Zn > Cr > Mn > Cu > Cd > Pb. Similarly, in both samples the concentration of Pb was below the detection level (Tables 1 and 2).

*Gonia fish:* In samples from both Cox's Bazar and Saint Martin's regions, the highest and the lowest concentrations were observed for Fe and Cd, respectively. The concentration of Pb was below the detection level. The concentration hierarchy of the heavy metals were Fe > Zn > Cr > Mn > Cu > Cd > Pb (Tables 1 and 2).

*Chhuri fish:* In samples from both Cox's Bazar and Saint Martin's regions, the highest and the lowest concentrations were observed for Fe and Cd respectively. The concentration of Pb was below the detection level. For Cox's Bazar samples, the concentration hierarchy of the heavy metals were Fe > Cr > Mn > Cu > Cd > Zn > Pb while for samples from Saint Martin's regions showed the hierarchy of the heavy metals as follows: Fe > Zn > Cr > Cu > Mn > Pb > Cd (Tables 1 and 2).

*Sundori fish:* In samples from both Cox's Bazar and Saint Martin's regions, the highest and the lowest concentration were observed for Fe and Cd respectively. For samples from Cox's Bazar, the concentration hierarchy of the heavy metals were Fe > Zn > Cr > Mn > Cu > Cd > Pb while for samples from Saint Martin's regions the concentration hierarchy were Fe > Zn > Cr > Cu > Mn > Cd > Pb. The concentration of Pb was below the detection level in samples from both the regions (Tables 1 and 2).

*Chepa fish:* In samples from both Cox's Bazar and Saint Martin's regions, the highest and the lowest concentrations were observed for Fe and Cd, respectively. For both the samples from Cox's Bazar, the concentration hierarchy of the heavy metals were Fe > Zn > Cr > Mn > Cu > Pb > Cd, respectively and the concentration of Pb was below the detection level in samples from both regions (Tables 1 and 2).

*Rupchanda fish:* In Cox's Bazar samples, the highest amount of Fe (19.6859 ppm) and the lowest amount of Cd (0.0191 ppm) was found. The concentration hierarchy of the heavy metals were Fe > Cr > Zn > Mn > Cu > Cd > Pb, respectively. Similarly, in samples from Saint Martin's regions exhibited the

highest amount of Fe (53.3143 ppm) and the lowest Cd (0.0221 ppm). The concentration of Pb was below the detection level in both cases (Tables 1 and 2).

*Feowa fish:* In Cox's Bazar samples, Feowa accumulated the highest amount of Fe (15.5554 ppm) and the lowest Cd (0.1428 ppm). The concentration hierarchy of the heavy metals were Fe > Zn > Cr > Cu > Mn > Cd > Pb, respectively in case of Feowa dried fish. Again Feowa fish collected from Saint Martin's regions showed the highest amount of Fe (16.4778 ppm) and the lowest amount of Cd (0.01339 ppm). The concentration hierarchy of the heavy metals was Fe > Zn > Cu > Cr > Mn > Pb > Cd (Tables 1 and 2).

*Phasa fish:* Phasa accumulated the highest amount of Fe (66.7872 ppm) and the lowest Cd (0.0633 ppm) in case of Cox's Bazar samples. The concentration hierarchy of the heavy metals were Fe > Zn > Cr > Cu > Mn > Cd > Pb. On the other hand, Phasa fish collected from Saint Martin's regions showed that muscle contained the highest amount of Fe (16.0078 ppm) and the lowest Cu (0.1161 ppm). The concentration hierarchy of the heavy metals were Fe > Cr > Zn > Mn > Cd > Pb (Tables 1 and 2).

*Correlation matrix of heavy metals in dried fish from Cox's Bazar and Saint Martin's regions:* Pearson's correlations matrix was determined among heavy metals in dried fishes from Cox's Bazar and Saint Martin's region (Tables 3 and 4). These correlations of coefficient were calculated among seven metals to identify, where there were presence of positive or negative linear association between metals.

**Table 3. Correlation matrix among heavy metals in dried fish samples from Cox's Bazar region**

	Cr	Pb	Cd	Cu	Mn	Zn	Fe
Cr	1.00						
Pb	0.0611	1.00					
Cd	-0.3752*	0.09990	1.00				
Cu	0.4109	0.1543	0.4540	1.00			
Mn	0.7699*	0.7558*	0.2001	0.311	1.00		
Zn	-0.0785	-0.3036	0.0168	0.5042*	-0.0842	1.00	
Fe	-0.0842*	0.5957*	0.20036	0.2698	0.6267*	0.2523	1.00

\*\*Correlation is significant at the 0.01 level (2-tailed).

For the samples of Cox's Bazar region, significant positive correlations were found between Cr and Mn (0.7699), Pb and Mn (0.7558), Fe and Mn (0.6267), Pb and Fe (0.5957) and Zn and Cu (0.5042). These metal pairs indicated the similar sources of pollution in dried fish. However, most of the metals in fishes were not significantly correlated even some showed negative correlation, which indicated

different anthropogenic and natural sources in fish samples (Table 3) while for the samples of Saint Martin's region exhibited significant positive correlations between Cr and Cd (0.1723), Cr and Fe (0.1843), Pb and Mn (0.5327), Pb and Fe (0.6261) and Zn and Cu (0.6236) (Table 4).

**Table 4. Correlation matrix among heavy metals in dried fish samples from Saint Martin's region**

	Cr	Pb	Cd	Cu	Mn	Zn	Fe
Cr	1.00						
Pb	-0.2121	1.00					
Cd	0.1723*	0.9863	1.00				
Cu	0.2521	-0.02543	0.651	1.00			
Mn	-0.6542*	0.5327*	-0.1343*	-0.421	1.00		
Zn	0.0875	-0.15632	0.08763	0.62362*	-0.0977	1.00	
Fe	0.1843*	0.6261*	0.07654	0.43241	0.1372	0.0541	1.00

\*\*Correlation is significant at the 0.01 level (2-tailed).

**Cd:** Fish samples from Cox's Bazar exhibited the highest concentration of Cd in dried phasa (0.0633 ppm) and the lowest in dried Rupchanda (0.0156 ppm). On the other hand, fish samples from Saint Martin's region showed the highest concentration of Cd in dried Phasa (0.1386 ppm) and the lowest concentration in dried Bashpati (0.0597 ppm). In this study, Cd concentrations were lower than those reported earlier (Mendil *et al.* 2005) in fish from Turkish Lakes. Our research values were found to be lower than the acceptable limit proposed by the (EU 2008 and Batten *et al.* 1999). The European Community proposed threshold values of metal concentrations in fish muscle of only 0.05 µg/g of Cd. (EC 2006). Cd can be accumulated with metallothioneins and uptake of 3 - 330 mg/day is toxic and 1.5 - 9 mg/day is lethal to humans (Mansouri *et al.* 2013). Cd injures kidneys and causes symptoms of chronic toxicity, including impairment of kidney function, poor reproductive capacity, hypertension, tumours and hepatic dysfunction (Waalkes *et al.* 2000).

**Cu:** In Cox's Bazar samples, the highest concentration of Cu was found in dried Gonia (0.1925 ppm) and the lowest in dried Mola (0.0473 ppm). On the other hand, samples from Saint Martin's showed the highest concentration of Cu in dried Feowa (0.5801 ppm) and the lowest in dried Loittyia (0.0566 ppm). In our study, Cu concentrations are lower than the values from earlier reports (Chele *et al.* 2002). The copper contents in the samples were much less than the FAO-permitted level of 30µg/g. Excessive intake of copper may lead to liver cirrhosis, dermatitis and neurological disorders (Toth *et al.* 1997).



*Mn*: The highest concentration of Mn was found in dried Chhuri (0.4026 ppm) and the lowest in dried Loittya (0.0924 ppm) in Cox's Bazar samples while samples from Saint Martin's region exhibited the highest concentration of Mn in dried Mola (0.4675 ppm) and the lowest in dried Loittya (0.0924 ppm). Mn concentrations in all the fishes were lower than the safe limit (1 ppm) recommended by FAO (1983).

*Pb*: The highest concentration of Pb was found in dried Chepa (0.1056 ppm) and the lowest in dried Gonia (0.0277 ppm) in Cox's Bazar samples. On the other hand, samples from Saint Martin's showed the highest concentration of Pb in dried Rupchanda (0.4625 ppm) and the lowest in dried Bashpati. These levels were found to be lower than 0.30 mg/kg set by EU (2008) except dried Rupchanda, hence there is a potential risk of Pb poisoning or toxicity when Rupchanda is consumed. Exposure to Pb may cause nervous system damage, paralysis and pain in the extremities (Nolan 2003).

*Fe*: The highest concentration of Fe was found in dried Phasa (66.7872 ppm) and the lowest in Loittya (9.3841 ppm) in samples from Cox's Bazar. On the other hand, samples from Saint Martin's region showed the highest concentration of Fe in dried Rupchanda (30.3143 ppm) and the lowest in dried Mola (09.7269). Fe exhibited the positive correlation with Cr and Pb.

*Zn*: The highest concentration of Zn was found in dried Phasa (1.7525 ppm) and the lowest in Mola (0.1473 ppm). On the other hand, fish samples from Saint Martin's region showed the highest concentration of Zn in dried Sundhori (1.7914 ppm) and in dried Loittya (0.194 ppm). According to Haque *et al.* (2003) the maximum permissible Cu and Zn levels were 10 - 100 and 30 - 100 mg/kg for fish respectively. Since the levels of Cu and Zn were lower than the maximum permissible levels, it may be concluded that consumption of this species from the coastal region is not a problem for human health.

*Cr*: Cr concentration varied from 8.5352 to 0.163 ppm in Cox's Bazar samples and the highest concentration was found in dried Rupchanda (0.0633 ppm) and the lowest in dried Feowa (0.0156 ppm). Fishes from Saint Martin's showed the highest concentration of Cr in dried Phasa (0.84452 ppm) and the lowest concentration in dried Rupchanda (0.1743 ppm). Cr does not normally accumulate in fish and hence low concentration was reported even from the industrialized part of the world. A study reported that the rate of uptake was higher in young fish but the body burden of Cr declined with the age due to rapid elimination (Datta 1993). In this study the observed concentration level is much lower than the permissible limits of 1-12 ppm recommended by (USFDA, 1993). A significant ( $p < 0.05$ ) relationship between Cd levels in fish from Cox's Bazar and Saint Martin's region was found while no significant differences were

observed in Cr levels in fish from Cox's Bazar and Saint Martin's region. Manganese in fish from Cox's Bazar and Saint Martin's showed significant difference ( $p < 0.05$ ) while no significant difference was observed in Fe level in fish from Cox's Bazar and Saint Martin's area.

Pravakar *et al.* (2013) conducted heavy metal investigation on three marine dried fish species. The results showed that concentrations of Cd and Cu were 0.28-1.3  $\mu\text{g/g}$  in Chinese Pomfret; 0.71- 2.1  $\mu\text{g/g}$  in Bombay duck and 0.35 -4.1  $\mu\text{g/g}$  in Ribbon fish indicating the acceptable quality of the traditional marine dried fish products. In the present study, the concentrations of Cd and Cu were much lower than the previous reports.

Rahman *et al.* (2012) worked on concentrations of eight heavy metals (Pb, Cd, Ni, Cr, Cu, Zn, Mn, and As) in the muscles of ten species of fish collected from Bangshi river at Savar in Bangladesh and found their concentrations below the safe limit thus there was no indication of pollution.

Raknuzzaman *et al.* (2016) determined seven trace metal concentrations (Cr, Ni, Cu, Zn, As, Cd and Pb) in some commercial fishes and crustaceans collected from coastal areas of Bangladesh. Trace metals in fish samples were in the range of Cr (0.15 - 2.2), Ni (0.1 - 0.56), Cu (1.3 - 1.4), Zn (31 - 138), As (0.76 - 13), Cd (0.033 - 0.075), and Pb (0.07 - 0.63 mg/kg wet weight (ww), respectively. Arsenic (13 mg/kg ww) and Zn (138 mg/kg ww) concentrations were remarkably high in fish of Cox's Bazar due to the interference of uncontrolled huge numbers of hatcheries and industrial activities. The elevated concentrations of Cu (400), Zn (1480) and As (53 mg/kg ww) were also observed in crabs of Cox's Bazar which was considered as an absolutely discrepant aquatic species with totally different bioaccumulation pattern.

The present study showed that, Fe was the most and Cd was the least accumulated metal in the dried fish species from Cox's Bazar and Saint Martin's areas. This pollution may be from industries or from drainage lines which are connected with the Bay of Bengal. There is also a possibility of heavy metal contamination during handling and processing of fish samples. From the human health point of view, this study showed that there were no possible health risks of heavy metal contamination to consumers from the coastal regions of Bangladesh.

## CONCLUSIONS

The concentration of heavy metals in dried fish sample were Cd:  $0.0191 \pm 0.02$  -  $0.0633 \pm 0.001$ ; Cr:  $0.163 \pm 0.025$  -  $8.5352 \pm 0.03$ ; Mn:  $0.0924 \pm 0.002$  -  $0.4026 \pm 0.034$ ; Fe:  $9.3841 \pm 0.05$  -  $66.7872 \pm 0.01$ ; Zn:  $0.1473 \pm 0.065$  -  $1.8146 \pm 0.045$  and Cu:  $0.047 \pm 0.05$  -  $0.198 \pm 0.06$ . The order of heavy metals in the

fish samples were Fe > Zn > Cr > Cu > Mn > Cd > Pb. Comparatively high concentrations of heavy metals were found to be accumulated in Mola (*Amblypharyngodon mola*), Rupchanda (*Stromateus chinensis*) and Chhuri (*Trichiurus lepturus*). In almost all the studied fish species, the concentration of Pb was below the detection limit but the concentration of heavy metals were within the international permissible limit given by WHO/EU except the concentration of Fe in fish Chhuri collected from Cox's Bazar and Saint Martin's regions. The findings of the present study indicated that the dried fish samples of the regions under study were safe for human consumption and appeared to be no immediate threat to these fish species from heavy metal contamination. Further investigation on the bioaccumulation and effects of heavy metals on fish and other aquatic biota are required to understand the effects of pollutants in aquatic environment.

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